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In re Patent Application of: Robert T. Gallagher
Title: DIGITAL RETURN PATH FOR HYBRID FIBER/COAX NETWORK
Attorney Docket No.: 500.714US1

PATENT APPLICATION TRANSMITTAL

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- X Specification (15 pgs, including claims numbered 1 through 22 and a 1 page Abstract).
- X Informal Drawing(s) (5 sheets).
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By: Chris Hammond
Signature: Chris Hammond

Digital Return Path for Hybrid Fiber/Coax Network

Technical Field of the Invention

The present invention relates generally to the field of telecommunications and, in particular, to a digital return path for a hybrid fiber/coax network.

Background

Cable networks originally carried programming from an head end to subscribers over a network of coaxial cable. Over time, these networks have changed. Some cable networks now include fiber optic links as part of the network. This variety of cable network is colloquially referred to as an "hybrid fiber/coax" network.

An hybrid fiber/coax network typically includes an head end that broadcasts programming over the network to subscribers in a downstream direction. The network includes two main portions. The first portion of the network is optical links that connect the head end with a number of geographically dispersed distribution nodes. These nodes are referred to as "optical distribution nodes" or "ODNs." At the ODNs, signals from the head end that carry the programming are converted from optical signals to electrical signals. The second portion of the network is coaxial links that connect the ODNs with subscriber equipment. The electrical signals are transmitted to the subscriber equipment over the coaxial cable links.

In recent years, the cable industry has experimented with systems that allow for bi-directional communication between subscriber equipment and the head end. This would allow for services such as video-on-demand, telephony and Internet traffic to be offered over a cable network. The upstream communication is typically reserved for transmission in the 5 to 42 MHZ frequency range.

One problem with such as system is the quality of signals that are transmitted over this return path from the subscriber equipment to the head end. The signals are subject to problems such as distortion and noise. Further, it is difficult to measure the effect of these influences on the signals.

For the reasons stated above, and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art for an improved return path for a hybrid fiber/coax network.

Summary

The above mentioned problems with telecommunications systems and other problems are addressed by the present invention and will be understood by reading and studying the following specification. A hybrid fiber/coax network is described which uses digital, baseband transmission in the reverse link between the optical distribution node and the head end.

Brief Description of the Drawings

Figure 1 is a block diagram of an embodiment of a hybrid fiber/coax network constructed according to the teachings of the present invention.

Figure 2 is a block diagram of one embodiment of a transmitter in an optical distribution node for a return path of a hybrid fiber/coax network according to the teachings of the present invention.

Figure 3 is a block diagram of one embodiment of a receiver in a head end for a return path of a hybrid fiber/coax network according to the teachings of the present invention.

Figure 4 is a block diagram of another embodiment of a transmitter in an optical distribution node for a return path of a hybrid fiber/coax network according to the teachings of the present invention.

Figure 5 is a block diagram of another embodiment of a receiver in a head end for a return path of a hybrid fiber/coax network according to the teachings of the present invention.

Detailed Description

The following detailed description refers to the accompanying drawings which form a part of the specification. The drawings show, and the detailed description describes, by way of illustration specific illustrative embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be used and logical, mechanical and electrical changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense.

I. Hybrid Fiber/Coax Network with Digital Return Path

Figure 1 is a block diagram of an embodiment of a hybrid fiber/coax network, indicated generally at 100, and constructed according to the teachings of the present invention. Network 100 is a bi-directional network that carries signals between head end 102 and a number of users.

For simplicity in describing network 100, the users are represented in Figure 1 by subscriber equipment 104. It is understood that network 100 can serve any appropriate number of users. Further, network 100 can support a wide variety of subscriber equipment including, but not limited to, audio/video, data, and telephony equipment.

Head end 102 is coupled to subscriber equipment 104 over a combination of fiber optics and coaxial cable. Namely, head end 102 is coupled via fiber optic link 105 with optical distribution node 106. Optical distribution node 106 is also coupled to coaxial cable links or branches 108. Typically, optical distribution node 106 supports up to four coaxial links 108. However, any appropriate number of links can be used to carry signals between optical distribution node 106 and subscriber equipment 104 through the use of multiple output broadband amplifiers 111 or splitters 109.

Subscriber equipment, represented by subscriber equipment 104, is selectively coupled to coaxial links 108 via taps 110.

Advantageously, network 100 uses baseband digital transmission to carry upstream signals from optical distribution node 106 to head end 102 optical fiber link 105. Typically, these upstream transmissions are accomplished in the 5 to 42 MHZ band. However, other transmission formats can be used to carry the upstream transmissions in network 100. At optical distribution node 106, the upstream frequency band is converted from an analog signal to a baseband, digital signal by an upstream transmitter. Exemplary embodiments of a transmitter for optical distribution node 106 are shown and described with respect to Figures 2 and 4.

Additional data may also be added to the digital signal, e.g., signals that monitor the status of the optical distribution node, the bit error rate link performance monitor. This digital signal is then transmitted over optical link 105 to a receiver at head end 102 that converts the digital signal back to analog form for processing by the head end.

The use of baseband, digital transmission in the upstream over optical link 105 provides several advantages over traditional analog transmission. For example, the performance of the return path over link 105 can be monitored in real time. This provides, among other advantages, the opportunity to for real-time analysis of data integrity, e.g., monitoring bit error rate link performance monitoring. Further, the field set-up of the optical distribution node is simplified over conventional approaches since issues related to, for example, complex balancing of tilt, level and average power in analog equipment to achieve optimum analog laser performance have been removed.

II. Transmitter for Digital Return Path

Figure 2 is a block diagram of an embodiment of a transmitter, indicated generally at 200, in an optical distribution node for a return path of a hybrid fiber/coax network according to the teachings of the present invention. Transmitter 200 includes bandpass filter 202 coupled to receive input from 1 to 4 coaxial links. Typically, signals from four coaxial links are coupled to bandpass filter 202 through 4 to 1 combiner 201. Each coaxial input to combiner 201 shares the same frequency spectrum. In one embodiment, bandpass filter 202 selectively passes signals in the 5 to 42 MHZ frequency range. The analog signals from bandpass filter 202 are provided to analog to

digital converter (ADC) 204 to convert the signals to baseband digital signals. The output of ADC 204 is an n bit wide signal, e.g., 10 bits. ADC 204 samples the analog signal from the coaxial links and produces 850 to 1000 Mega-bits per second with a 10 bit wide ADC 204. An analog to digital converter that operates at this rate is AD9070, commercially available from Analog Devices, of Norwood, MA. The digital output of ADC 204 is converted to a serial data stream by multiplexer (MUX) 210.

MUX 210 also can add other data to the serial data stream. For example, status information from status monitor 206 can be added. Status monitor 206 provides information on the operation of the optical distribution node to the head end of the hybrid fiber/coax network. Further, other data 208 can also be provided. This data includes framing data and data for bit error rate link performance testing.

MUX 204 is coupled to optical transmitter 214 through laser drive amplifier 212. Optical transmitter comprises, for example, a 1310 nanometer, digital laser that transmits data with a bit rate of up to approximately 1 Gigabits per second. This bit rate is approximately a SONET OC-24 bit rate. A digital laser that operates in this manner is part no. 1241FCDC, commercially available from Lucent Technology of Murray Hill, NJ. Other digital lasers can also be used that operate at different wavelengths, e.g., 1550 nanometers, and with different data rates.

Optical transmitter 214 provides this optical signal to a head end over an optical fiber.

III. Receiver for Digital Return Path

Figure 3 is a block diagram of one embodiment of a receiver, indicated generally at 300, in a head end for a baseband, digital return path of a hybrid fiber/coax network according to the teachings of the present invention. Receiver 300 includes an optical receiver, e.g., avalanche photo diode, that is coupled to receive optical signals over an optical fiber from an optical distribution node. An acceptable optical receiver is the 1319P that is commercially available from Lucent Technology, of Murray Hill, NJ.

Optical receiver 302 is coupled to clock data recovery device (CDR) 306 through transimpedence amplifier 304. In one embodiment, CDR 306 is based on a

SONET OC-24 type of clock data recovery device commercially available from Lucent Technologies of Murray Hill, NJ. CDR 306 recovers the clock signal (CLK) used in transmitting the optical signals over the optical fiber. Further CDR 306 separates out the data from the received digital signal. CDR 306 maintains the data synchronous with the clock signal.

CDR 306 is coupled to provide the data and the CLK signal to decode logic 308. Decode logic 308 is coupled to demultiplexer (DMUX) 310. Decode logic 308 aligns the start of data information to DMUX 310 with respect to the framing start that is generated by other data block 208 of Figure 2. All data is position encoded with a frame. Decode logic 308 detects frame start and position by bit.

DMUX 310 separates data from the digital signal that was added to the digital data stream at the optical distribution node. For example, DMUX 310 separates out data from a status monitor and provides this information to block 314. This information can be used by the head end to control the operation, or monitor the operation of the optical distribution node. Further, DMUX 310 provides other data 208 that was added to the digital signal to other data block 312. This other data may include, for example, data for determining a bit error rate link performance or other appropriate data. Finally, DMUX 310 provides an n-bit signal to digital to analog converter (DAC) 316. This signal corresponds to the digitization of the upstream signal received by the optical distribution node. DAC 316 converts this signal to an analog signal. An appropriate DAC for this function is the AD9731 commercially available from Analog Devices, of Norwood, MA.

DAC 316 is coupled to filter 318. Filter 318 compensates for the effect of quantization in the analog to digital conversion at the optical distribution node by use of a (sin x)/x function. The output of filter 318 is analog data that is provided to the head end for processing, e.g., the output of filter 318 is an analog signal in the 5 to 42 MHZ frequency range.

IV. Alternative Embodiment for Transmitter for Digital Return Path

Figure 4 is a block diagram of another embodiment of a transmitter, indicated generally at 400, in an optical distribution node for a return path of a hybrid fiber/coax network according to the teachings of the present invention. Transmitter 400 includes bandpass filters 402a, 402b, 402c, and 402d. to receive input from four separate coaxial links. Bandpass filters 402a, 402b, 402c, and 402d pass signals in the 5 to 42 MHZ frequency range. Other frequency ranges can be used for the upstream communications.

This embodiment implements a digital form of "block conversion" such that each coaxial link can use the full 5 to 42 MHZ frequency spectrum. Conventionally, upstream transmission in a hybrid fiber/coax system is limited by the fact that each of the coaxial links coupled to a common optical distribution node uses the same frequency spectrum to carry signals from users to the head end. Thus, the coaxial links cannot make full use of the upstream spectrum without potentially interfering with each other when combined at the optical distribution node. Block conversion has been used in some systems so that the upstream communications on the coaxial legs are frequency shifted at the optical distribution node such that each coaxial link can use the full 5 to 42 MHZ frequency spectrum. This is referred to as "block conversion."

In this embodiment, the effect of block conversion is achieved with digital signals; namely, each coaxial leg can use the full upstream spectrum, e.g., 5 to 42 MHZ. When signals from the multiple coaxial links are combined at the optical distribution node. The signal from each coaxial link is separately filtered and converted to digital format. Then, the separate digital signals are combined into a higher bit rate digital signal for transmission to the head end. Thus, this embodiment accomplishes the advantages of block conversion in the digital domain.

The analog signals from bandpass filters 402a, 402b, 402c, and 402d are provided to analog to digital converters (ADCs) 404a, 404b, 404c, and 404d, respectively. ADCs 404a, 404b, 404c, and 404d convert the signals from bandpass filters 402a, 402b, 402c, and 402d, respectfully, to baseband digital signals. ADCs 404a, 404b, 404c, and 404d each provide an "n" bit wide signal, e.g., 10 bits as a digital output. ADCs 404a, 404b, 404c, and 404d each sample their respective analog signals

from the bandpass filters 402a, 402b, 402c, and 402d and produce 850 to 1000 Megabits per second with 10 bit wide ADCs 404a, 404b, 404c, and 404d. An analog to digital converter that operates at this rate is AD9070, commercially available from Analog Devices, of Norwood, MA. The digital output of ADCs 404a, 404b, 404c, and 404d are each converted to a serial data stream by multiplexers (MUXs) 410a, 410b, 410c, and 410d, respectively.

MUXs 410a, 410b, 410c, and 410d are coupled to multiplexer 411 to create a digital data stream for transmission to the head end. Additional information also can be added to the serial data stream output by multiplexer 411. For example, status information from status monitor 406 can be added. Status monitor 406 provides information on the operation of the optical distribution node to the head end of the hybrid fiber/coax network. Further, other data 408 can also be provided. This data includes, for example, framing data and data for bit error rate link performance testing.

MUX 411 is coupled to optical transmitter 414 through laser drive amplifier 412. Optical transmitter 412 comprises, for example, a 1310 nanometer, digital laser that transmits data with a bit rate of up to approximately 5 Gigabits per second. This bit rate is approximately a SONET OC-96 bit rate. A digital laser that operates in this manner is E2560, commercially available from Lucent Technologies of Murray Hill, NJ. Other digital lasers can also be used that operate at different wavelengths, e.g., 1550 nanometers, and with different data rates.

Optical transmitter 414 provides this signal to a head end over an optical fiber.

V. Alternative Embodiment for Receiver for Digital Return Path

Figure 5 is a block diagram of another embodiment of a receiver, indicated generally at 500, in a head end for a baseband digital return path of a hybrid fiber/coax network according to the teachings of the present invention. Receiver 500 includes an optical receiver, e.g., avalanche photo diode, that is coupled to receive optical signals over an optical fiber from an optical distribution node. An acceptable optical receiver is the 1319TP that is commercially available from Lucent Technology, of Murray Hill, NJ.

Receiver 500 works with signals that implement a digital form of block conversion such as described above with respect to Figure 4.

Optical receiver 502 is coupled to clock data recovery device (CDR) 506 through transimpedence amplifier 504. In one embodiment, CDR 506 is based on a SONET OC-96 type of clock data recovery device commercially available from Lucent Technologies of Murray Hill, NJ. CDR 506 recovers the clock signal (CLK) used in transmitting the optical signals over the optical fiber. Further CDR 506 separates out the data from the received digital signal. CDR 506 maintains the data synchronous with the clock signal.

CDR 506 is coupled to provide the data and the CLK signal to decode logic 508. Decode logic 508 is coupled to demultiplexer (DMUX) 509. Decode logic 508 aligns the start of data information to DMUX 509 with respect to the framing start that is generated by other data block 408 of Figure 4. All data is position encoded with a frame. Decode logic 508 detects frame start and position by bit.

DMUX 509 separates data from the digital signal that was added to the digital data stream at the optical distribution node. For example, DMUX 509 separates out data from a status monitor and provides this information to block 514. This information can be used by the head end to control the operation, or monitor the operation of the optical distribution node. Further, DMUX 509 provides other data ~~509~~ 408 that was added 3/9/99 to the digital signal to other data block 512. This other data may include, for example, data for determining a bit error rate link performance or other appropriate data. Finally, DMUX 509 separates the remaining data into a number of channels corresponding to the coaxial links that provided the data to the optical distribution node. This data is provided to demultiplexers (DMUXs) 510a, 510b, 510c, and 510d. DMUXs 510a, 510b, 510c, and 510d each provide an n-bit wide signal, e.g., 10 bits, to digital to analog converters (DACs) 516a, 516b, 516c, and 516d, respectively. These signals correspond to the digitization of the upstream signal received by the optical distribution node from each of the coaxial links. DACs 516a, 516b, 516c, and 516d each convert their respective signals to an analog signals. An appropriate DAC for this function is the AD 9731 commercially available from Analog Devices, of Norwood, MA.

DACs 516a, 516b, 516c, and 516d are coupled to filters 518a, 518b, 518c, and 518d, respectively. Filters 518a, 518b, 518c, and 518d compensate for the effect of quantization in the analog to digital conversion at the optical distribution node by use of a (sin x)/x function. The output of filters 518a, 518b, 518c, and 518d are analog data streams that are provided to the head end for processing, e.g., the output of filters 518a, 518b, 518c, and 518d are analog signals in the 5 to 42 MHZ frequency range.

Conclusion

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. For example, the upstream signals can be transmitted in a different frequency spectrum. Further, other wavelengths can be used to transmit the digital signals over the optical link between the optical distribution node and the head end. The optical distribution nodes can also be coupled to any appropriate number of coaxial links.

What is claimed is:

1. A hybrid fiber/coax network, comprising:

a head end;

at least one optical distribution node coupled to the head end over at least one fiber optic link;

a plurality of coaxial cable links coupled to each of the at least one optical distribution node;

a transmitter, disposed at the optical distribution node, that is responsive to signals from the plurality of coaxial cable links, that converts analog signals to baseband digital signals and that transmits the baseband digital signals to the head end over the at least one optical link; and

a receiver, disposed at the head end, that is responsive to the baseband digital signals from the transmitter and that converts the digital signals to analog signals for the head end.

2. The network of claim 1, wherein the transmitter includes a analog to digital converter that is operable to generate at least 850 Megabits per second.

3. The network of claim 1, wherein the transmitter separately converts signals from the plurality of coaxial cables into separate, n-bit signals, and combines the separate n-bit signals into a serial data stream.

4. The network of claim 1, wherein the transmitter incorporates data from a status monitor in the baseband digital signal transmitted to the head end.

5. The network of claim 1, wherein the transmitter incorporates bit error rate link performance data into the baseband digital signal transmitted to the head end.

6. The network of claim 1, wherein the transmitter combines signals from the plurality of coaxial cables prior to converting the signals to baseband digital signals.

7. A transmitter for an optical distribution node, the transmitter comprising:

at least one bandpass filter that is operable to select a portion of the frequency spectrum that is associated with return path signals for a hybrid fiber/coax network;

at least one analog to digital converter, responsive to the at least one bandpass filter, that creates baseband digital data from the return path signals;

at least one multiplexer, responsive to the at least one analog to digital converter, that creates a serial data stream from the baseband digital data from the at least one analog to digital converter; and

an optical transmitter, responsive to the at least one multiplexer, that is operable to transmit the serial data stream to a head end as a digital baseband signal.

8. The transmitter of claim 7, and further including a monitor that monitors the operation of the optical distribution node and that creates status data for transmission to a head end in the serial data stream.

9. The transmitter of claim 7, wherein the bandpass filter include a pass band in the range from 5 to 42 MHZ.

10. The transmitter of claim 7, wherein the at least one analog to digital converter includes one analog to digital converter for each coaxial link associated with the transmitter.

11. The transmitter of claim 7, wherein the at least one multiplexer comprises:

one first stage multiplexer for each coaxial link associated with the transmitter; and

an additional multiplexer coupled to the output of each of the first stage multiplexers.

12. The transmitter of claim 7, and further including bit error rate link performance data that is coupled to the at least one multiplexer to be included in the serial data stream.

13. A method for processing data in a return path of a hybrid fiber/coax network, the method comprising:

receiving analog, upstream data at an optical distribution node;

generating baseband digital data from the analog, upstream data;

creating a serial data stream including the digital data; and

driving a digital laser to transmit the digital data in a baseband digital format to a head end of the network.

14. The method of claim 13, wherein generating digital data comprises sampling the analog, upstream data at a rate of at least 850 Megabits per second.

15. The method of claim 13, wherein creating the digital data stream comprises multiplexing at least one n-bit digital data stream into a serial data stream.

16. The method of claim 13, wherein creating the digital data stream comprises multiplexing a number of n-bit digital data streams into a serial data stream.

17. The method of claim 13, wherein receiving analog, upstream data at an optical distribution node comprises receiving analog, upstream data from a number of coaxial links.

18. A receiver for a digital data return path of a head end in a hybrid fiber/coax network, the receiver comprising:

an optical receiver that is operable to receive a serial, digital baseband signal from an optical link;

at least one demultiplexer, responsive to the optical receiver, that demultiplexes the digital baseband signal;

at least one digital to analog converter, responsive to the at least one demultiplexer, that creates analog signals for the head end; and

at least one filter that is operable to compensate for quantization effects in the frequency spectrum that is associated with return path signals for a hybrid fiber/coax network.

19. The receiver of claim 18, wherein the at least one demultiplexer removes status data for the head end from the serial baseband signal.

20. The receiver of claim 18, wherein the at least one digital to analog converter includes one digital to analog converter for each coaxial link associated with the receiver.

21. The receiver of claim 18, wherein the at least one demultiplexer comprises:

one first stage demultiplexer for each coaxial link associated with the receiver; and

an additional demultiplexer coupled to the output of each of the first stage demultiplexers.

22. The receiver of claim 18, wherein the at least one demultiplexer removes bit error rate data from the serial baseband signal.

Abstract of the Disclosure

A hybrid fiber/coax network is provided. The network includes a head end with at least one optical distribution node coupled to the head end over at least one fiber optic link. A plurality of coaxial cable links are coupled to each of the at least one optical distribution node. Further, a transmitter is disposed at the optical distribution node. The transmitter is responsive to signals from the plurality of coaxial cable links. The transmitter converts analog signals to baseband digital signals and transmits the baseband digital signals to the head end over the at least one optical link. A receiver is disposed at the head end. The receiver is responsive to the digital signals from the transmitter and converts the digital signals to analog signals for the head end.

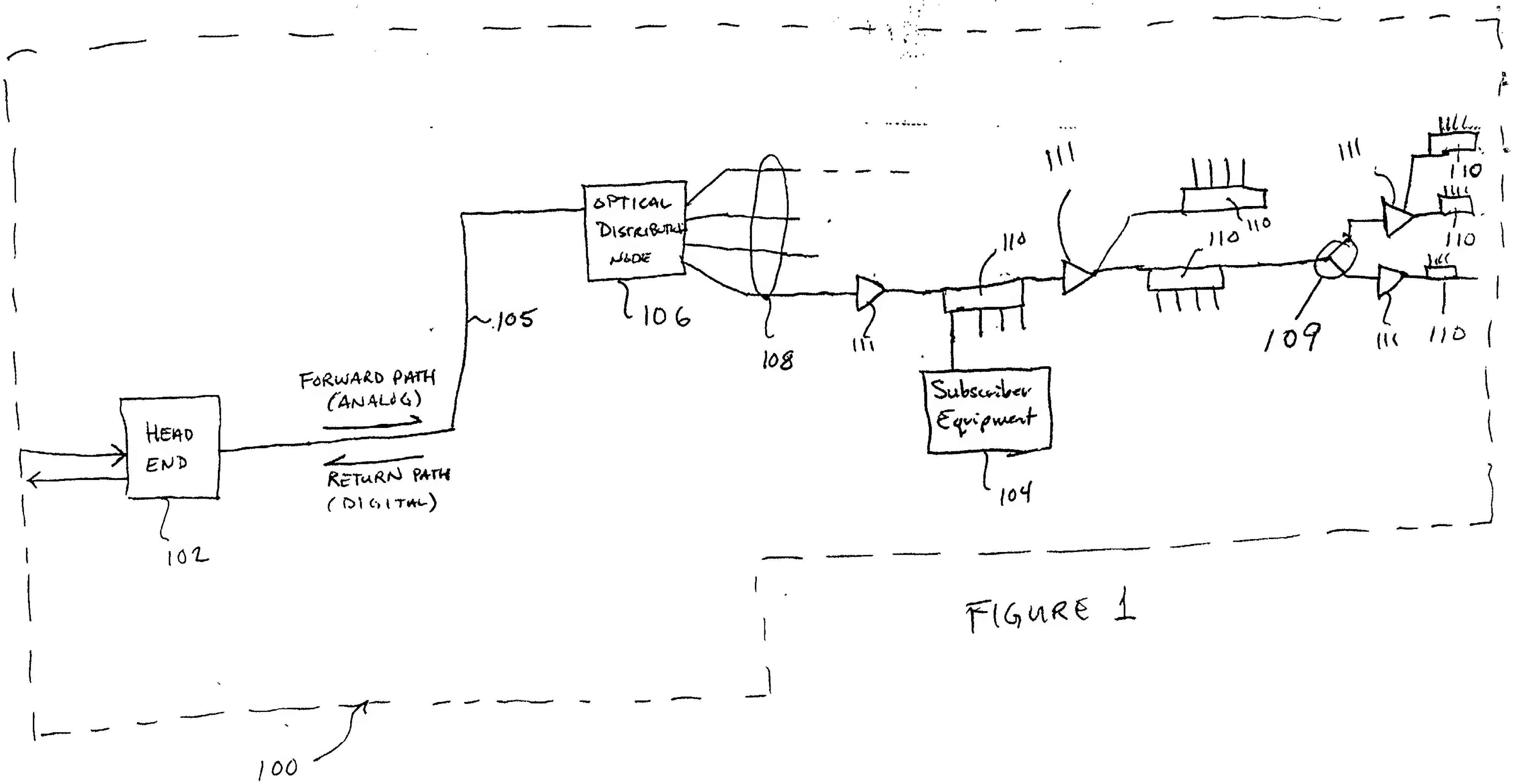

OPTICAL DISTRIBUTION NODE
106
105
108
HEAD END
102
FORWARD PATH (ANALOG)
RETURN PATH (DIGITAL)
Subscriber Equipment
104
110
111
109
100

FIGURE 1

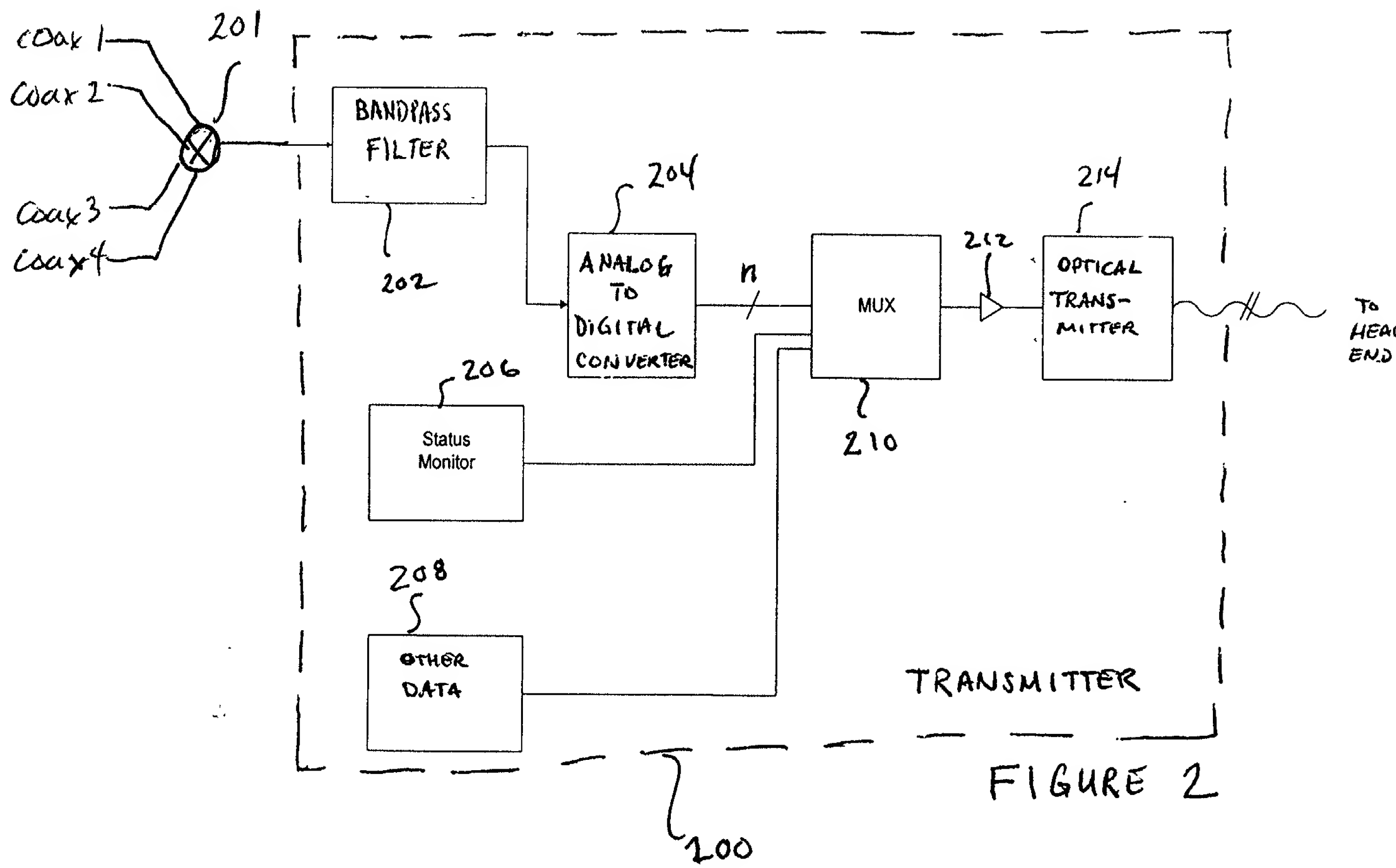
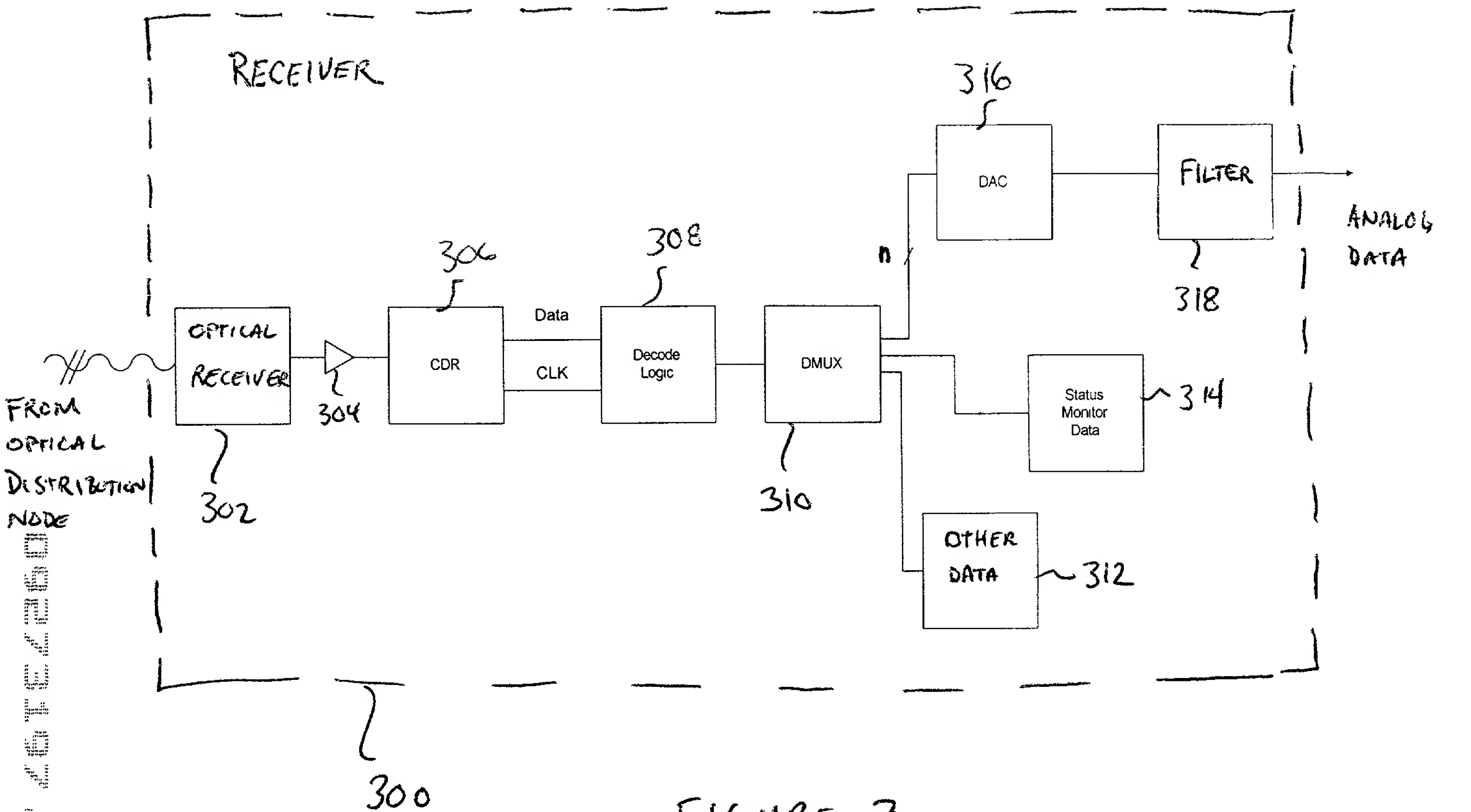
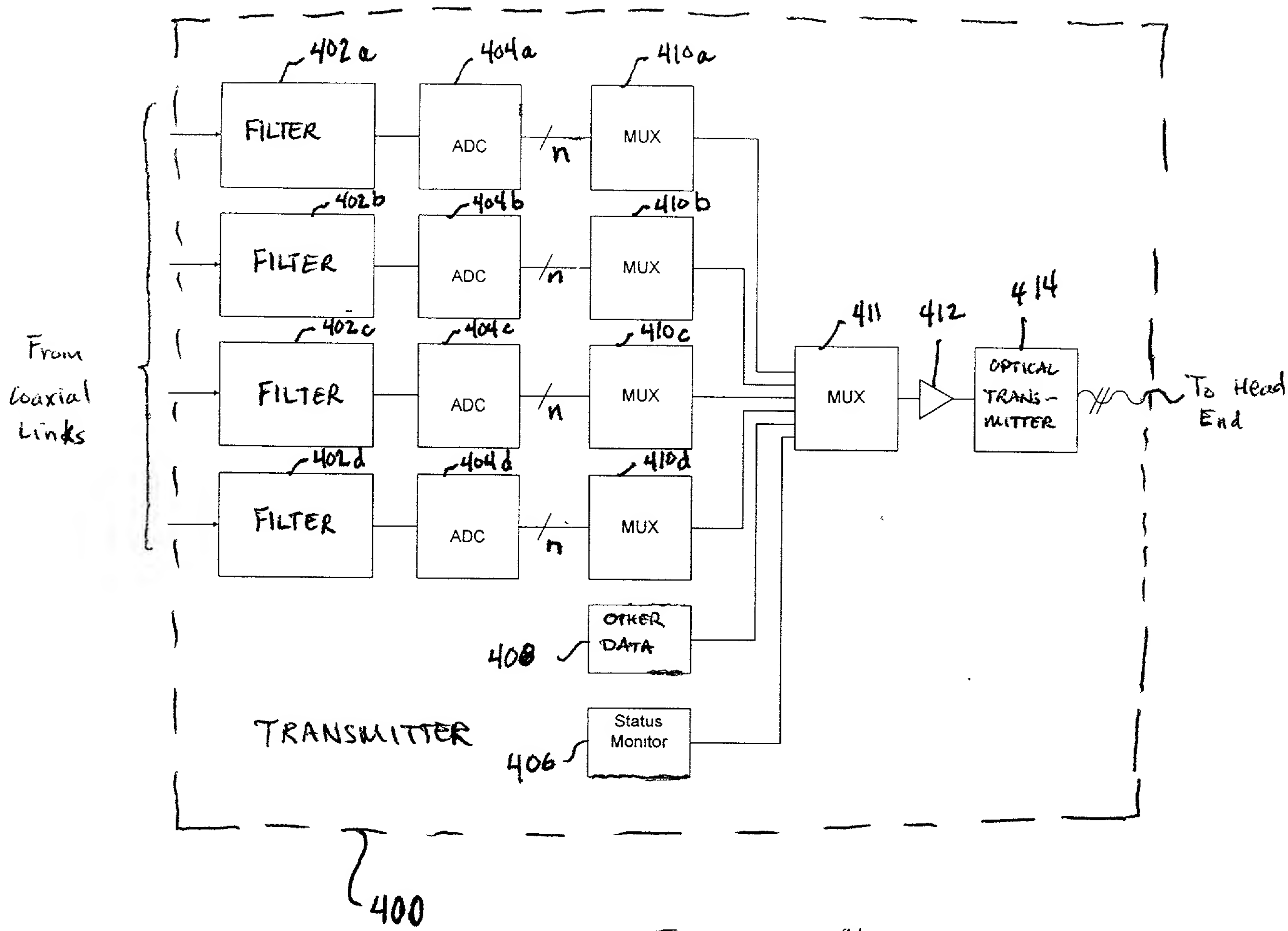

coax 1
coax 2
coax 3
coax 4
201
BANDPASS FILTER
202
204
ANALOG TO DIGITAL CONVERTER
n
206
Status Monitor
208
OTHER DATA
MUX
210
212
214
OPTICAL TRANS-MITTER
To HEAD END
TRANSMITTER
200

FIGURE 2



RECEIVER
OPTICAL RECEIVER
FROM OPTICAL DISTRIBUTION NODE
302
304
CDR
306
Data
CLK
Decode Logic
308
DMUX
310
n
DAC
316
FILTER
318
ANALOG DATA
Status Monitor Data
314
OTHER DATA
312
300

FIGURE 3



402a
404a
410a
FILTER
ADC
n
MUX
402b
404b
410b
FILTER
ADC
n
MUX
402c
404c
410c
FILTER
ADC
n
MUX
402d
404d
410d
FILTER
ADC
n
MUX
From
Coaxial
Links
411
412
414
MUX
OPTICAL
TRANS-
MITTER
To Head
End
OTHER
DATA
408
TRANSMITTER
Status
Monitor
406
400

Figure 4

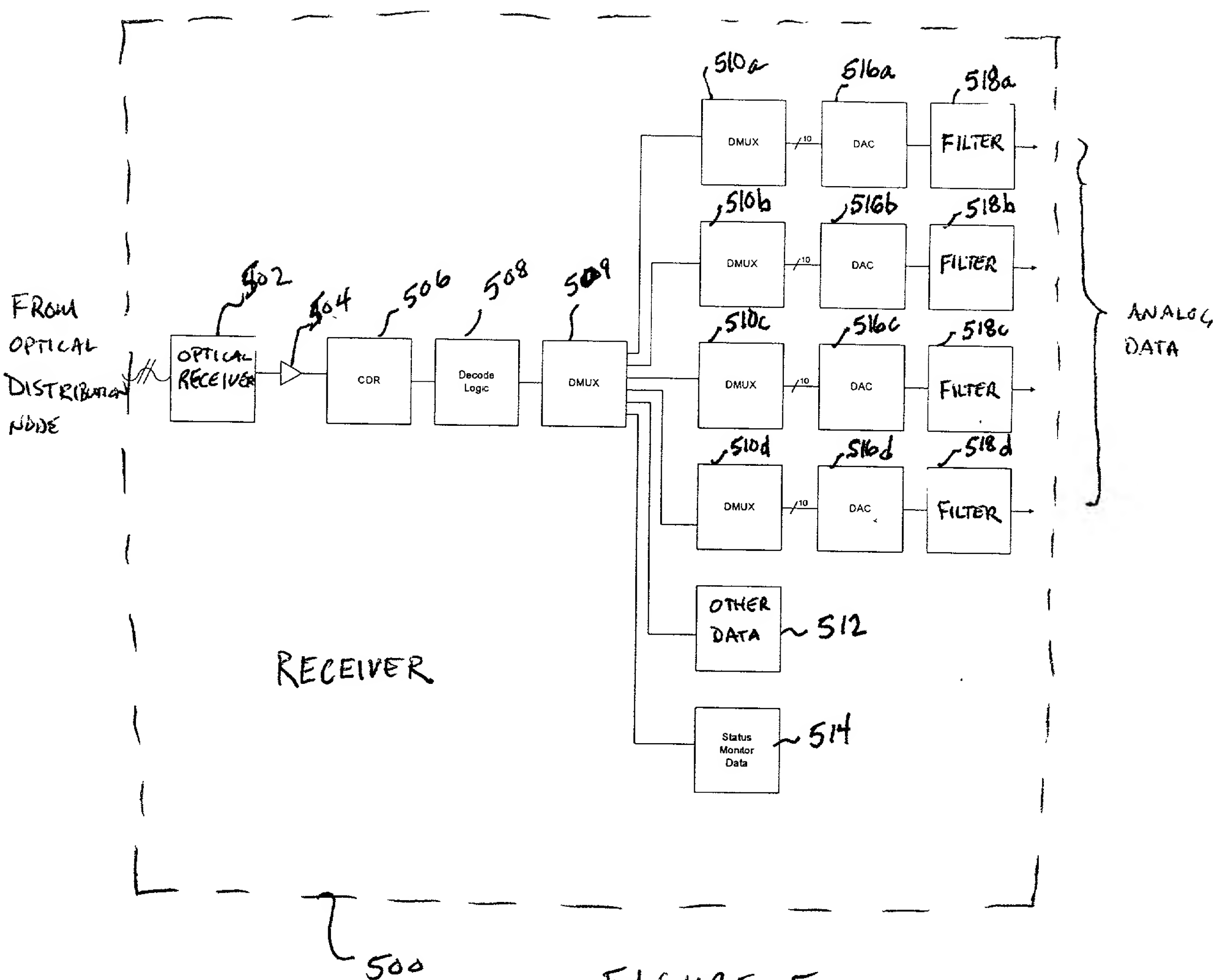

FROM OPTICAL DISTRIBUTION NODE
OPTICAL RECEIVER
502
504
CDR
506
Decode Logic
508
DMUX
509
DMUX
510a
DAC
516a
FILTER
518a
DMUX
510b
DAC
516b
FILTER
518b
DMUX
510c
DAC
516c
FILTER
518c
DMUX
510d
DAC
516d
FILTER
518d
10
ANALOG DATA
OTHER DATA
512
Status Monitor Data
514
RECEIVER
500

FIGURE 5

SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: **DIGITAL RETURN PATH FOR HYBRID FIBER/COAX NETWORK**.

The specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (see page 3 attached hereto).

I hereby claim foreign priority benefits under Title 35, United States Code, §119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

No such claim for priority is being made at this time.

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

No such claim for priority is being made at this time.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

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Arora, Suneel	Reg. No 42,267	Harris, Robert J.	Reg. No. 37,346	McCrackin, Ann M.	Reg. No 42,858
Bianchi, Timothy E.	Reg. No. 39,610	Holloway, Sheryl S	Reg. No. 37,850	Padys, Danny J.	Reg No. 35,635
Billion, Richard E.	Reg. No. 32,836	Huebsch, Joseph C.	Reg. No 42,673	Polglaze, Daniel J.	Reg. No. 39,801
Black, David W	Reg No. 42,331	Kalis, Janal M	Reg. No 37,650	Schwegman, Micheal L	Reg No 25,816
Brennan, Thomas F.	Reg No. 35,075	Klima-Silberg, Catherine I	Reg No. 40,052	Sieffert, Kent J	Reg No 41,312
Brooks, Edward J , III	Reg No 40,925	Kluth, Daniel J.	Reg No 32,146	Slifer, Russell D	Reg No 39,838
Clark, Barbara J.	Reg No 38,107	Lacy, Rodney L	Reg No. 41,136	Steffey, Charles E	Reg No 25,179
Drake, Eduardo E	Reg No. 40,594	Leffert, Thomas W.	Reg. No. 40,697	Terry, Kathleen R	Reg No. 31,884
Dryja, Michael A.	Reg No. 39,662	Lemaire, Charles A	Reg. No 36,198	Viksnins, Ann S.	Reg. No 37,748
Embretson, Janet E	Reg. No. 39,665	Litman, Mark A.	Reg. No. 26,390	Woessner, Warren D.	Reg No 30,440
Fogg, David N.	Reg No. 35,138				

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/ firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Schwegman, Lundberg, Woessner & Kluth, P.A. to the contrary.

Please direct all correspondence in this case to Schwegman, Lundberg, Woessner & Kluth, P.A. at the address indicated below:

P.O. Box 2938, Minneapolis, MN 55402
Telephone No. (612)373-6900

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of sole inventor : **Robert T. Gallagher**
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Signature: Robert T. Gallagher Date: 3/9/99
Robert T. Gallagher

Full Name of inventor:
Citizenship: Residence:
Post Office Address:

Signature: Date:

Full Name of inventor:
Citizenship: Residence:
Post Office Address:

Signature: Date:

Full Name of inventor:
Citizenship: Residence:
Post Office Address:

Signature: Date:

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§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application:

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.